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ABSTRACT

Industry representatives reviewed the curricula for computer programmer-analyst, network administrator, and technical support courses at 10 community colleges in California. Thirty-eight reviewers participated in the focus groups, and several other reviewers participated via e-mail. The focus groups discussed each of the three degree programs separately. Reviewers offered specific suggestions targeted to each course and noted the competencies needed for the three occupations and the usefulness of industry certification and community college certificates and degrees. They also considered future trends, such as continued growth, evolving technologies, new business models, new types of worker and employer relationships, new skills and types of workers, and new training models. Recommendations include the following: (1) more collaboration between colleges and industry to provide student and faculty internships, share facilities, and recruit short-term faculty from industry; (2) partnerships among college administrative computer divisions and instructional programs; (3) continued industry reviews of curriculum; (4) curriculum that includes nontechnical competencies such as communications, problem solving, and teamwork; (5) emphasis on lifelong learning; (6) continued instructor contact with industry to become aware of trends; and (7) a field-based component in every curriculum. (Questions for the curriculum review and future issues are appended to the document.) (KC)

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Information Technology Curriculum Collaborative
for the
Community Colleges of the East Bay

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Industry Review and Validation of Model Curriculum for Programmer/Analyst, Network Administration, and Technical Support

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Industry Review and Validation of Model Curriculum for Programmer/Analyst, Network Administration, and Technical Support

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Introduction

Recent estimates target information technology (IT) as a key job growth area in the East Bay Area region with as many as 40,000 IT jobs in this region (White, 1999). To help meet the need for trained IT workers, four East Bay community college systems are developing and aligning their IT programs to industry validated skill standards. This work is part of the Regional Workforce Economic Preparation and Development Act (RWEPDA) EASTBAY *Works* consortium.

The ten community colleges, led by Peralta Community College District, have focused on the development of model curricula in three IT occupational cluster areas: Computer Programmer/Analyst, Network Administrator, and Technical Support. Participating community colleges include: College of Alameda, Chabot College, Contra Costa College, Diablo Valley College, Laney College, Las Positas College, Los Medanos College, Merritt College, Ohlone College, and Vista Community College.

This development work builds off the national level skill standards in IT, *Building a Foundation for Tomorrow: Skill Standards for Information Technology* (NorthWest Center for Emerging Technologies, Bellevue Community College). WestEd has assisted with review and validation of the model curricula, convening focus groups of representatives of the high tech industry in the greater East Bay Area.

This report summarizes the results of the review and validation process and offers recommendations to the project for aligning the curricula and programs to local industry needs.

Methodology

Working from lists of high technology companies in the East Bay Area collected from the Internet, community college faculty and staff, and recommendations of employees in the high tech industry, WestEd staff contacted over 130 companies for participation in focus groups. The charge of the focus groups was to provide feedback on draft model programs and course descriptions. We targeted larger companies that impact the job market in the East Bay and could be expected to want continued involvement with the evolving community college programs. Participants from smaller companies were also recruited, but due to time constraints and fewer numbers of employees it was difficult for these companies to provide focus group participants. In fact, several employers cancelled their attendance the day of a meeting due to client emergencies for technical support, testimony to the demand for these services and the 24 hours a day 7 days a week nature of many jobs in the high tech industry.

A total of thirty-eight reviewers participated in the focus groups, while several other reviewers provided feedback via email. Table 1 displays the number and type of reviewers for each program area and lists participating companies.

Table 1
Number and Type of Reviewers by Program Area and Companies Represented in the Focus Groups

Program Area	Number of Participants	Companies Represented
Computer Programmer/ Analyst	6 industry representatives 2 educator observers	A Vail Able Technologies Lawrence Berkeley National Laboratory Cisco Systems Kinecta PeopleSoft WestEd
Network Administrator	9 industry representatives 3 educator observers	Bank of America National Semiconductor Corporation CompUSA Forty Plus of Northern California Intel Corporation Lawrence Livermore Nat'l Laboratory
Technical Support	16 industry representatives 2 educator observers	Lawrence Berkeley National Laboratory City of Livermore Hacienda Data Systems Hudson Humanware Intel Corporation Lawrence Livermore National Laboratory MAR_COM The Partnership Tri-Valley Scholarship Fund Xstream Data

WestEd convened two focus groups per curriculum area within a one-week period. Reviewers provided feedback and suggestions after reviewing the model curriculum for the program area of their expertise. Each of the community college model curricula will be discussed in turn.

Computer Programmer/Analyst

The focus groups discussed each of the three degree programs in this curriculum separately. Both of the Computer Programmer/Analyst focus groups agreed that the Associate of Science (AS) in Computer Programming was valuable and the courses appropriate. An overall discussion of the courses is presented below as part of the course-by-course review.

One group thought the Associate of Arts (AA) in Information Technology should reflect web technology (AA in Web Technology). The degree would be directed towards Web and Internet work, particularly development of web sites. The graduate would work with a team of data programmers, business people, and marketing experts to provide integration between the underlying technology and business processes. Courses with more liberal arts content as applied to technology need to be added (i.e., degree should include graphic design, data analysis, global commerce, and technical writing). Topics in C1-Foundations of Computer Programming, C2-Intermediate course in any programming language, and C4-Systems Analysis or Software Engineering should be web-focused. Content should include user interface, database access, client-side scripting, usability and testing, HTML and static content, and page and site design.

Both groups thought the AS in computer science should reflect University of California transfer requirements. The calculus course could be dropped unless the student will be transferring into a four-year program and might need to take more calculus later on.

Course-by-Course Review

Reviewers offered specific suggestions targeted to different courses as follows:

- What is intended in the CP6-Operating Systems class? The course description needs more detail. There should be a distinction made between an interface and the underlying kernel and I/O architecture. Students will deal with the interface and, possibly, administration of the system. Content needs to include scripting of commands, automation, file structure, retrieval, and security.

- What is the relationship between the CP1-Foundations of Computer Programming and the CP2-Intermediate course in any programming language? Should students focus on more than one language? The first level deals with concepts and logical constructs, the second and later courses add real programming skills and language specific skills. Students need to learn two languages (one procedural, one object-oriented). Three languages are probably too much.

- Is Object/Oriented Analysis included in CP4-systems Analysis or Software Engineering? The course should emphasize Unified Modeling Language (UML) and O/O Analysis techniques instead of structured analysis. UML has become an industry standard but not many schools include this area yet.

- What is the goal in CP5-Database Management? Students need to be able to code to the general needs of database programmers and know how to use a database. CP7-Business Data Structures should be more about deploying databases in a business environment. Programmers should know SQL and maybe some database management on a particular platform. The sequence might be a) data structures, b) database buildings, and c) applications, testing, and tuning. The final database course could actually be a "capstone" to provide a tie–up of all the program concepts. Students need to learn rudimentary database, data structures, introduction to globs, e-commerce, security issues, data mining (statistical inference), trends (data analysis).

- What should students learn in B1-Technical Communications/Technical Writing? This course could be taught in the English department, not as a creative writing class, but emphasizing communications, presentations, and teamwork. The skills needed are not "user manual" writing, which is generally a team effort. Rather, a programmer should be able to write a good specification (spec) or outline about a job to be done. Where would the student learn how to use PowerPoint or even Word? This might be a "Technical Communications and Presentations" course. One reviewer suggested using source control for team projects so instructors can track which parts of the code a student worked on and any changes that were made.

In addition to these general suggestions summarized from the focus groups, one of the reviewers recommended that students should have some knowledge of SQL.

> *SQL is basically the standard that is currently tying all of the databases together, that are being used out there...I think SQL is here to stay, so it wouldn't be a bad idea to teach them...You probably wouldn't have to spend a whole course talking about SQL, but maybe a week or two covering SQL and giving them just a background in it.*

Another reviewer recommended adding business management/entrepreneurism to the curriculum.

> *When you pilot the business courses, you might want to include a section that covers how to form a company from beginning to end...what it takes. The days of the start-ups are here and a lot of companies are sink or swim, I've learned a lot from being with a bunch of small companies. Where they fail is that when they start growing, they start having these tremendous growing pains, and the only way a start-up survives is by addressing those growing pains and being able to identify them before they pop and explode.*

Technical and Non-technical Competencies

Across both focus groups, reviewers agreed that all the technical competencies were valuable. One focus group thought that the technical competency J-Project Management would be difficult for students to achieve in a 2-year program and also suggested adding a competency called Creating Project Plans and Project Lifecycles.

During the discussions of the non-technical competencies the following issues were raised:

- Teamwork is vital. Programmers need to be able to share process ideas, opinions, and to communicate with patience and some facility with peers and supervisors. They need to appreciate the value of what others have contributed. An emphasis in all three programs should be team-based projects. Other comments regarding teamwork follow:

    - Why not have a course where all three groups (computer programmer/analyst, web technologist/information technologist, transfer computer science student) are brought together to do a project? This could be framed as a project internship and businesses and 4-year colleges could partner with the community college in making it happen.

    - Teamwork can also be included in the Technical Communications/Technical Writing course.

    - Instructors could use source control for team projects to track which parts of the code students worked on and any changes that were made.

    - Team skills training/exposure should be integrated across the curriculum and across the tracks as much as possible, not as a course or chapter in a book, but as an instructional orientation.

    - Teamwork should be promoted through individual assignments, communication of individual work to the group, mutual aid, peer tutoring, etc.

- Life-long learning is important. Can a worker pick up a skill on the job? Can they extend their knowledge on their own? The course curriculum can provide opportunities to either extend learning beyond the classroom (research, open lab, etc.) or to instill out-of-the-box problem solving (brainstorming in a team).

- Questioning and listening skills are important. Programmers and technology workers need to feel comfortable asking questions and in letting others ask them questions.

Specifically, reviewers in one group suggested adding the following non-technical competencies: a) Writing Resumes, b) Job-hunting, Getting, and Preparing for an

Interview, c) Leadership, d) Dealing with Difficult Employees, e) Conflict Resolution, and f) Assertiveness Training. The other group added other non-technical competencies: a) Self-confidence, b) Sense of Personal Responsibility, and c) Ability for Self-learning.

Industry Certifications and Community College Certificates and Degrees

Although the standard in the field is a Bachelor's of Science (BS) or Bachelor's of Arts (BA) with well-established competence, one group saw opportunities for a technician level programmer. If a 4-year degree is not really critical in a specific job opportunity, then a certificate can be useful.

> *Even if the job is saying BA/BS recommended, I think they would look at the best package. If somebody came to them with a portfolio that showed over this 2-year period they worked on teams, they worked in these languages, etc., versus a BA in classics or a BA in underwater basketweaving or whatever, I think they'd be hard-pressed to choose one over the other.*

However, reviewers across both groups agreed that a 2- or 4-year degree is assumed to demonstrate more willingness to learn and more education in liberal arts (better communications, work habits, and commitment) than a certificate.

In making hiring decisions, employers look for work experience. One reviewer recounted his own experiences weeding through job opportunities during a job search and finally returning to the company where he had done an internship.

> *I went though the whole process of getting my portfolio together, getting my resume together, sending it out, making all kinds of contacts, and everything else, because I wanted my resume to speak for itself. I wanted my education to speak for itself. And so I passed it out, sent it everywhere, except Cisco, because that's where I did my internship. I just wanted to see how far it would fly. One of the comments I got back from one of the leaders in industry (not Cisco) was, "Well if we hired everybody with a master's degree..." They wanted to see my experience in the field...experience to them was more important than the degree to get in.*

In summary, one reviewer believed the 2-year programs responded to the current needs of industry for workers in this area.

> *I think that from an industry standpoint this is excellent. This is exactly what we need. I firmly believe that there is a labor crisis right now, and this would take a big step toward solving that. We have got to get more people into the workforce more quickly, because we're just falling behind. We're not falling behind anybody in particular, we're just falling behind. There's just more stuff to be done that can be done. Why should we wait? There are good people out there and we ought to give them good jobs and let them contribute.*

Network Administrator

A major theme from the focus groups focused on adding more details to the suggested Network Administrator curriculum. The course categories include: core courses, Network Connectivity (CCNA), Netware System Administration (CNA), UNIX Systems Administration I and II, and Windows Systems Administration (MCSE). These categories are comprehensive, but not all courses in each category contained the same level of detail. For example, industry reviewers immediately noticed the lack of depth and detail in the Windows System Administration category when compared to the Netware System Administration category.

Course-by-Course Review

Looking at the most valuable elements of the curriculum, reviewers reported that all courses are important.

> *I don't think there is much question, at least in my mind, the relevancy that there's the networking, the CISCO concentration, the network concentration, UNIX concentration, and then Microsoft, and those are the big players in the industry right now. So having a skill set in those areas, it might be a very valuable thing. And it looks like you picked out what would be the basis for certification of those four different areas. If that's the case, then I think it's perfect.*

They did suggest incorporating more details into various categories. Below are suggestions for the core courses category:

- Embed technical communication (e.g., documentation, technical writing, and oral presentations) in the introductory courses. B1-Technical Communications/Technical Writing should be named Career Communications.
- Include instruction on printing networks, such as how to configure and make choices.
- Add a course titled, "Overview of Network Security," covering network intrusive firewalls, network analysis, use of proxy servers, load balancing, buffers, routers, and information security (e.g., internal and external).
- And as a counterpart to the Windows Operating Systems core course, include an introduction to the Macintosh platform because more organizations are using Macintosh web servers to secure those systems from potential "hackers," as there are no command prompts and no scripting in Macintosh systems.
- Add a small course which would introduce the specialty areas (i.e., operating systems, platforms, network systems). The purpose would be to expose students to different pathways within the degree which will be important at large schools that offer all pathways.
- Add an Internship/Field Experience course as part of the core.

Regarding the remaining four course categories, reviewers commented that the four categories presented a comprehensive overview of network administration. With regard

to specific courses, the major concern was the lack of detail in the Windows System Administration (MCSE) category. Reviewers suggested the following to be added to that category:

- Make the Windows System Administration category resemble the Netware System Administration (CNA) in how the electives are listed.
- Add one more course for a total of seven required courses, with three being electives (refer to MCSE requirements for possible electives).
- Include reference to Windows 2000, Internet information server, browser, mail server, Microsoft Exchange, and System Management Services (SMS).
- Include SQL.

In addition, reviewers made suggestions about the UNIX Systems Administration I and II category:

- Course NA14-Introduction to Networking is the same course as NA4 of the same title, a core course requirement, and can therefore be deleted in Systems Administration I.
- In the place of NA14, move NA17-Introduction to TCP/IP from Systems Administration II to Systems Administration I.
- In Systems Administration II, the first elective Applied Visual Basic Programming is not useful (page 13).
- Include in Systems Administration I, a short course or hands-on lab on the different versions of UNIX (i.e., Solaris, HP, AIX).
- And in Systems Administration II, LINUX could be offered as an elective.

Additional comments from industry reviewers include:

- It is attractive to employers if applicants have training in both the MCSE and the CCNA.
- Of the various industry certificates MCSE, CCNA, CNA, UNIX, and CNE – the CNE would be most valued (according to reviewers in the second focus group).
- Perhaps Network Security could be offered as a separate certificate.
- It is valuable if students have a hardware background.
- Those with UNIX background are in high demand.

Technical and Non-technical Competencies

Industry reviewers in the first focus group mentioned technical competencies N-Development and Implement Security Procedures, O-Define and Document Test Specifications, and P-Develop Test Plan and Procedures as important to focus instruction on because a vast majority of applicants lack these competencies. However, they did not rank order the technical or non-technical competencies because all on the lists are important, depending on the particular occupation, the frequency of having to perform tasks, and company demands.

However, some discussion surrounded non-technical competencies C-Client Relations and D-Professional Development/Self Learning in particular:

> *All of them [the six non-technical competencies]. These are skills that are sorely lacking in the applicant pool. Client relations is more important every day as we become more and more a service industry...and point D about professional growth and self learning. Getting the job is only the first obstacle. Maintaining your development is an ongoing, never-ending process.*

In the second focus group, reviewers did not rank the technical competencies, but ranked non-technical competencies C-Client Relations and F-Teamwork as most critical. They also stated that all competencies were important and varied depending on specific occupations, frequency of tasks, and company demands.

> *Very few jobs these days don't require some level of teamwork. And you have to be able to be both a member of the team and sometimes the leader of the team.*

When asked what might be missing from the list of non-technical skills, reviewers responded that planning skills were missing.

> *Planning. I think planning is sort of missing from there, like planning your day, planning your month, planning is very important.*

In addition, reviewers commented that rules of confidentiality and discretion need to be followed by network administrators because they have access to personal, sensitive, and secure information.

Industry Certifications and Community College Certificates and Degrees

The majority of employers in both focus groups favor applicants that have either an AA/AS or BA/BS with an industry certification. The industry certification alone is not enough to gain employment.

> *I have interviewed several people with just certifications or industry certifications on the side, and I have not been impressed with them. But I think that what happens is these certifications teach you how to pass the test. They do not teach you how to manage in an environment.*

Industry reviewers were concerned about an applicant's ability to think critically, problem solve, time manage, and most importantly communicate effectively – both orally and in writing. They believed that an AA/AS or BA/BS degree or an internship in the industry would signify more opportunities to demonstrate those critical skills. If the applicant had industry internships, they would be most likely to be hired because they have "real world" experience in the IT field. Employers would be taking less risk in hiring an intern (even without a degree) with a track record in the industry than hiring an applicant with only paper credentials.

Technical Support

Direction from the Technical Support focus groups was ambiguous. A major theme from the discussion was that the Technical Support curriculum had breadth, but needed more of a focus. Reviewers tended to disagree over what that focus should be (i.e., hardware, software, network). One of the groups characterized the curriculum as "hardware-heavy." In one group, a reviewer mapped out a curriculum process used at his company that charted levels of content knowledge (core/basic to more specific/advanced) against content areas (hardware, soft skills, applications/software). The group placed each course on the chart to help their thinking about what the program focus might be. This group thought there should be a software/application focus. The other group thought there should be a network focus and noted overlap with the network administrator curriculum, which offers more in-depth preparation in that area. Overall, industry reviewers recommended offering at least a few overlapping classes with the Network Administrator curriculum for students preparing for jobs with companies that have networks (i.e., most high tech companies run networks).

Both groups thought the degree should have a title that reflects more specificity: one group suggested Computer Systems Technical Support and the other suggested Technical Application Support.

Course-by-Course Review

Reviewers identified TS1-Concepts and Applications as a valuable course and identified logic and problem solving as critical skills for this work area. Reviewers wanted to see this logic and problem solving specifically defined in the curriculum as a unit or parts of several courses. Reviewers thought this content should be dealt with in ALL courses. Suggestions related to including logic and problem solving in the curriculum are:

- a curriculum from a Bank of America program that features Kempner Trego could be used as a model
- taking any basic class in logic (may be offered through another department) would be useful
- incorporation of hands-on troubleshooting in complex networked environments where many components interact and could go wrong is essential
- students should learn to use systematic approaches to reasoning out or isolating the problem and document each step
- problem tracking and documentation is an es[illegible]l skill

Also valuable are TS3-Introduction to Operating Systems, and NA1-Networking Fundamentals. Introduction to Operating Systems (TS3) should provide students with the tools and techniques to enable them to install and configure most common operating systems. An advanced course could address issues related to OS installation and configuration in networked environments.

The Advanced Electives could be more valuable if students were required to focus in one area. One group suggested requiring students to take 3 related electives. For example, one of Microsoft's certificates (MSCE) requires 7 classes. Students interested in Windows and Microsoft would take 3 of these courses. The intent would be to learn the "essential Microsoft stuff" and to create a foundation they can later build on.

TS5-Introduction to Computer Hardware & TS6-Computer Systems Configuration could include additional content. For these courses, the project needs to add computer security (suggested topics included available products, different configurations, monitoring procedures, and how to log this information), security authentication, and entitlement (i.e., access and firewalls). These courses should also include virus detection, safety (in computing environments), ergonomics (related to safety), electrical (related to safety), and how to recognize packaging hazards when setting up new equipment. Students should participate in at least one lab where they take apart a desktop computer and diagnose and repair a problem, then reassemble.

Both groups agreed that the lab element in the curriculum was critical for technical support students. Technical support is "getting your hands dirty" and installations are not always "Plug and Play." These students really require the hands-on troubleshooting and actual "doing it." The following is a suggested list of activities to include over the course of the program.

- Open a PC, identify it, and identify the manufacturer and model number of pieces or parts. These can become critical in an installation. Replace a basic card.
- Hook up, configure accesses, and share data between LINUX workstation and Unix server, NT server, NT workstations. Run applications that live on UNIX and NT platform servers from LINUX workstation. Add different cards and peripherals to LINUX workstation.
- Practice working with Enterprise applications.
- Install a variety of software packages in a networked and non-networked environment.
- Install an e-mail pack, make sure that it can talk to the outside world, and send an e-mail.
- Install a web browser with proxy servers.
- Install firewalls. Troubleshoot problems related to access and firewalls (layers). Acquire tools and understanding of who has access.
- Practice remote management (hard/soft). Troubleshoot from the perspective of how everything works together.
- Install a modem and configure the comports appropriately.

- Change a network interface card (NIC).
- Back-up a hard disk back-up using different methods.
- Understand the capacity on a PC.

Reviewers liked the concept of TS7-Co-op Ed, Field Experience. or Helpdesk Practicum. However, the course description should be revised to include field experience in industry placements and computer lab staffing. Both groups suggested making this element an internship or a piece of an internship. Important skills for technical support employees are human relations and problem solving. The function of this element is not only to have people go out and get some real experience, but to deal with irate customers, to troubleshoot and assess problems quickly, and to troubleshoot over the phone.

> *When somebody's got something wrong with their computer, they are irate. You're the first one there, and it's always us... it's not personal. How do you defuse the situation? How do you make them feel comfortable? A lot of customers think they know what's wrong with their computers and think that they didn't do anything wrong. You have to figure out a way to get information out of them, a diplomatic way of finding out what the real problem is and it's cause.*

The A+ certification program has a section that deals with customer relations, the appropriate questions to ask, how to approach the customer, and, specifically, what not to do. These particular materials might be useful for curriculum addressing these areas.

National labs, such as Lawrence Livermore and Berkeley, have established internship programs. These organizations, as well as other community resources, are vital for a strong internship program. Although companies use different qualifications and rules in selecting interns than they do employees, a successful internship can lead to a potential job offer. Reviewers agreed that "having interns come in is a great way to screen for the best one [applicant]." These kinds of experiences are especially important for new people entering the field. Students already working may find it difficult to participate in internship opportunities, due to time considerations, so making it a mandatory course might be difficult and unnecessary.

Similar to troubleshooting, communication is a fundamental piece of technical support work. S1-Technical Communications should be re-titled "Communications and Business Environments" or "Communications and Customer Support." An employer shared that his company liked to hire graduates from one specific college for two reasons: they are articulate and write well. These are skills that time after time graduates from this particular program have displayed, so that he thought it likely that any graduate from that institution will bring them to the table.

An industry representative noted that sometimes technical support staff are overwhelmed or at a loss in dealing with clients, which can affect their job opportunities.

You have no idea how many times we want to send a technical support person out to just go visit with a customer to talk about a very specific problem. You want to say, look, just go ahead and put together a power-point presentation with some slides, and go and do this. And they are like, well, power-point—I don't know. They just get lost, in that and in how to give a presentation to a client.

A reviewer in one group noted that her company had career ladders that offered advancement for technical employees. Classification tracks for advancement were technical, technical/administrative, and administrative. In the other group, reviewers identified career ladders at one large company that moved hardware-oriented support employees into network positions. Application-oriented support employees could move into many more positions, such as customer service representative, project manager, quality assurance, customer training, testing (writing script/test routines), business analyst, and sales support/training.

Technical and Non-technical Competencies

Employers ranked C-Installation/Configuration, J-Analysis, K-Problem Solving – Troubleshooting, L-Project Management, and M-Task Management as the most important technical competencies to be incorporated into the curriculum. They suggested updating the sub-competencies, particularly those for C-Installation/Configuration, so that Windows'98 NT is first, followed by less relevant versions, such as Windows '95 (delete Windows '93). These competencies should also include Solaris, LINUX, and Millennium.

Non-technical competencies should include:

- listening and interaction with clients as part of A-Business Communications;
- organizational/time management as part of E-Professional Environment, and
- team-building as part of F-Team Work.

Other technical and non-technical competencies that are important are math skills (percent, computation), knowledge of basic applications (EXCEL, Front Page, Word), how to present and sell yourself, and an understanding of where to pass the problem along to when its not yours to solve.

Employers universally agreed that they would hire an applicant that had completed the program. A small software company representative believed that, "If all objectives were satisfied as listed, the individual could virtually walk on water!"

Industry Certifications and Community College Certificates and Degrees

The majority of the technical support reviewers preferred hiring an employee with an AA/AS degree, if she had good technical skills. Job experience was a crucial factor across the board for all applicants and having customer support experience was preferable. One group ranked an AA/AS with a relevant industry certification as the most preferred combination. The other group similarly ranked the top applicant as an AA/AS with good technical skills. In order of preference, following the AA/AS, were a(n):

- certificate with relevant work experience;
- industry certification; and
- community college certificate.

A reviewer identified minimum requirements for an entry-level employee as customer service skills, communication skills, and a drive to learn the technical side. One group tended not to consider a 4-yr degree unless it was in a related area or the applicant had IT-related work experience. The other group thought that a 4-year degree was useful in that graduates could be expected to have well-developed communication and interpersonal skills and be better prepared to deal with customers.

Discussion of Future Trends

Industry representatives considered "over-the-horizon" trends in the information technology industry. Examining transcripts from these discussions, six overarching themes can be identified. Industry representatives foresaw continued growth in the industry, evolving technologies, emergence of new business models, new types of worker/employer relationships, demands for new skills and types of workers, and the need for development of new training models to ensure a fully prepared workforce for this fast-paced, changing industry.

A. Continued Growth

Our high-tech industry reviewers identified continued growth as a major trend in the future of the IT industry. They described technology as being at the "foot of the mountain" with everything eventually becoming, "more, better, faster, cheaper." Demand will grow with at least a 25% increase in jobs in IT for many years to come. The technology is rapidly evolving as more uses evolve and the whole industry becomes more service-oriented. There will be more support structure and a need for people to develop, sell, and support all the new and different technologies, particularly software (i.e., "less hardware, more applications support"). Not only will there be more and better technology ("things we can't even envision"), but broader infiltration of what already exists. The following excerpts from transcripts of the discussion by our industry reviewers exemplify these views.

> *The more service-oriented we become, as consumers, as industry, as anything, the more dependent we are on robot communication and uses for that are evolving every day. I don't see 20 years from now that there will be a lessening of that, and there may even be an increase. Technology evolves so rapidly, there are things that we don't even think yet that we'll be trying to shove into this environment. I think a 25% increase [in jobs] is probably even conservative.*

> *You can do anything given the technology to deliver it... even video over the Internet. Five years ago, people that I worked with laughed that it would happen for local area networks, let alone across the country or across the world. And now you talk to another person on the other side of the world, and it may not be the most beautiful thing at the moment, but I see that, in another five years, making that even more feasible, more reliable, and closer to real time. Now my microwave and my alarm clock auto set themselves for daylight savings time. They know what day of the year it is, and what year it is. And that's just a small chip. What's going to happen when they can not only do that, but download new settings, and firmware upgrades, all via talking through in-house connectivity?*

B. Evolving Technologies

Beyond this overwhelming vision for change and spiraling development, our reviewers identified specific technologies that they targeted for future "waves" of development and expansion in use. These technologies were:

- Fiber-optic cable in the office and home, which will result in unlimited bandwidth. Increased bandwidth will bring more opportunities and possibilities, video communication will become more reliable and accessible.

- More web development and more incorporation of JAVA into different programming languages. JAVA has set a new standard and has pervaded different programs. Not only will there be more demand for JAVA but there will always be a new JAVA (someone who develops a new script better than JAVA).

- Increased emphasis on wireless technology and combination of technologies (i.e., voice over IP, voice data, infrared, simultaneous and interactive, shared applications that are transmitted and interfaced with multiple locations).

An industry reviewer described JAVA development as an apex of current technology development.

> *One of the things that appears to be happening with programming languages is more and more demand and more and more incorporation of JAVA as a programming language. JAVA is something that a lot of other programming languages promise to be. They basically have taken the language and configured it to just about every aspect of network applications.*

Another reviewer agreed that,

> *JAVA has set a new standard that must be met and there will be, somebody will develop another JAVA. There will always be something that's running hot that's there and got to be met [the challenge of technology development].*

Given all these considerations (i.e., shared systems, etc.), security issues will become even more important than now and automation will become very important (or "technology doing the thinking for us").

C. New Business Models

Because of constant emergence of opportunities, high-tech companies will need to be flexible. Their "customers are the world," as one industry representative remarked, so office and work hours will need to be structured so they are adaptable to many different time zones and ways of doing business. Companies will need to have staffing 24-7 (i.e., 24 hours a day, seven days a week). Employees will need the skills to be able to work

effectively with multiple companies in different countries, in diverse settings and different cultures. Since there will be no geographic anchors (i.e., the corporate office may become a thing of the past) employees will increasingly work off-site or in different locations for short-term assignments. Virtual institutions or businesses will allow employees to work at home. As described by one industry representative,

> *Your customers are no longer the people in your neighborhood. They are the world. I support people in Pakistan, India, Korea, Japan, Great Britain, all over North America, South America, Australia, and all of them living in their time zone, all of them expect to be responded to at various times. All of them have different expectations about what that business is and how it is going to be connected, and we have to be the ones adapting to them. They don't have to adapt to us. We're providing the service. You go write [an email] at 3 a.m. in the morning, because it's somebody else's daytime. That's 10 a.m. for them.*

New business models are now developing. For example, the phenomenon of the "hired gun," a temporary employee with lesser or no benefits and no long-term commitments, will become increasingly predominant in the workplace. Outsourcing, or contracting out work rather than filling positions with full-time employees will become even more prevalent. With the wild influx of venture capital into the dot.com market, businesses will have to find cost-effective means of doing business (i.e., eventually start to show a profit). Industry representatives envisioned an untapped market of potential users, exemplified through the acceptance of email by groups, such as older people, as a way of talking to family and friends. As one industry reviewer suggested,

> *We come to a person in the IT field who's actually being treated as a hired gun. It is a very temporary kind of thing. You see that philosophy pervading some of the dot.coms that are coming on, where their life cycle is expected to be limited. They are getting the venture capital, they are running through that, then they are gobbled up by somebody else, they don't really expect to make the business profit. They are thinking in terms of the short term. And the fact that everything is temporary.*

Partnerships and work relationships between companies will be more in flux resulting in a "graying" of lines. One company may compete against another in some markets, yet merge or combine resources as partners in other markets. Reflecting the new work force, contractors who are increasingly independent agents will band together to create loosely framed groups to offer services (i.e., complimentary services for more comprehensive outsourcing).

> *You'll have a group of mountains of contract employees that will band together in some cooperative something or other. I'll go with a perfect example of being very successful is M^2, in San Francisco. They provide technical writing and consulting contracting support. I think you're going to see more and more of those.*

D. New Types of Worker/Employer Relationships

To accommodate these new business models, new types of employee/employer relationships are developing. The technology world is becoming more and more like contractor and contractee, rather than traditional employer and employee. Companies are fostering employee independence and flexibility by making it easy to have a "do-it-yourself lifestyle. Companies provide fewer traditional retirement plans and benefit plans but instead offer 401(K)s, stock options, and incentives (percentages of base salary based on production). The 401(K) can be portable and transferred when the employee changes jobs. Employees give up a sense of loyalty – to the company but also in general, to a platform or to a concept of a career. Employees will need to be able to move from place to place and to work with a variety of people, getting on board quickly and becoming immediately effective. An industry representative described the situation as follows:

> *Not only has the company you went to work for yesterday been swallowed up or is no longer in business in 5 years or less, you may have had 4 or 5 jobs in that 5 years. There are greater opportunities, but less employer loyalty to employees, and certainly less—and almost nonexistent—employee loyalty to employer.*

In part, this temporary mind set relates to company acquisitions. As companies are acquired by other companies, the job situation changes. As one industry representative put it,

> *Acquisitions happen every day. When I started working it was a reasonable expectation to go to work for somebody and retire in 25-30 years. Now it's not even a reasonable expectation that they'll have any kind of retirement program.*

Some large companies offer a variety of on-site services that (though employees may pay to receive them) help their employees cope effectively with a fast-paced commuter lifestyle. For example, one large Silicon Valley company offers health club memberships, dry-cleaning services, dog-walkers, a daily car wash, and medical services in a clinic on-site.

Typically, employment in this brave new world will not be measured in years, or even in months. Employees will be paid for what they deliver (i.e., cash for services provided) and will work anywhere (i.e., home, hotel space, virtual offices). Outsourcing will grow in acceptance; use of foreign nationals brought in to fill temporary positions will continue (i.e., H1-Bs exist because the technology industry has a shortage of trained workers). One industry representative commented that,

> *I think the trend is going to be that the company is not going to provide you with the tools, it's not going to provide you with the environment. It is going to pay you for what you deliver. You can deliver that out of your home, or the car, or off the beach in Hawaii if you want to. The company won't care. It won't give you lunch. It won't give you health benefits. It*

won't give you a retirement program. What it'll do is give you cash for services provided. And I think the vocation of the future is going to be fully integrated back into the family lifestyle, whereas you used to have a craftsman who worked out of his home, and he taught his child how to make chairs, or candles or leatherwork. I think you'll see a trend back that way. You're going to see dad and mom working out of the home, and the kids are going to learn the profession as they grow up.

Not all industry employees or employers are happy with these trends,

Employment will not be measured in years, it may not be measured in months. I think there's a real potential reality of millions of day-termers, contractors who are working simultaneously for any number of companies, any number of projects, and that is a never-ending cycle. Full-time regular employees are being reduced, and the contracts staff increased. The reality of lesser and fewer benefits. You have to take care of yourself, and I don't see it as a lifestyle. I see it as a forced lifestyle.

E. New Skills and Types of Workers

Changing business models and workers' roles call for new skills and types of workers. Independent contractors (i.e., mercenary workers) are proliferating. The concept of a career is being redefined as workers need diffuse skills to be able to float between companies and contracts. Employees need to "own" their own employability. As one industry representative described this trend,

That's a fundamental [assumption], that you own your own career. You are responsible for making your own employability. If you fail to do that, you're not going to have a job. And this floating employee, the higher up you want to go, the more that's your reality. You want to be a helpdesk support for your whole life, there will always be people providing real jobs in something that resembles what people consider in employment. If you want to step up, anywhere out of that first or second layer of industry, the reality is that neither the company nor the employee are going to tie together to a career of 20 years. Or even one year. You are going to float. You will apply your skills as you can, where you can, and continue to grow. And that does not lead to, particularly in the technologies, career placement. It leads to defining your own career and writing your own tasks, and managing your own retirement.

Students, then, need to learn to be very flexible and adaptable; people need to be prepared for life-long development and continual improvement of their skills. As one reviewer exclaimed, "Expect, anticipate, and embrace change!" Part of success in this environment can hinge on being able to "catch the wave" and workers need to be prepared to do so. Effective preparation means continuously updating knowledge and skills. This can include visiting web sites of other companies, industry rags, trade papers, the web sites related to those papers, and just looking to see what's coming down the pike. One reviewer noted that,

> *Product knowledge has a half-life, which is measured in months. You are buying into the requirement of ongoing learning and training and much of it you may have to acquire on your own.*

Working in a "shrinking world" lends new dimensions to leadership and teamwork skills. As workers strive for success on their team, which might be international, they are working with multiple people and diverse cultures over a variety of communication technologies (i.e., telephone, Internet, teleconferencing internationally). As one reviewer proclaimed, "It is not only what else is going on out there, but who else is involved in the team…success as a team and who's on your team, whether they are here or China or the Netherlands."

Language has become increasingly important as communication spans cultures and countries. Acronyms or techno-jargon have changed language. As an industry representative described,

> *We get more and more 3-letter acronym-based. Partly out of a time issue. Partly out of common ground. It is easier to remember what the 3-letter acronym stands for than maybe the 3 words, particularly if they are multi-syllabic techno-speak. An acronym is something that somebody who is a technician can grasp, someone who is an admin assistant can grasp, someone who's your customer can grasp, where not necessarily do the true words mean anything. But the acronym gets its own association. So I think there is a certain amount of language change. It increases the need for language, because we'll never be able to communicate in 100% 3-letter acronyms. And if you don't understand the fundamentals of language, than acronyms become meaningless at some point as well.*

Finally, workers need to create new technologies, ways of working, ways of thinking about problems and developing new solutions. In short, workers will need to cultivate "thinking out of the box." Because, as one reviewer described, work used to mean that an employee was

> *…going to work on assembly lines somewhere, fitting the same part for 20 years, retiring and going off in an RV. But now, 20 months from now, it's unlikely in the extreme that you'll be fitting the same parts. Or anything that even resembles the same parts—the product may be completely different.*

F. New Training Models

To meet these demands for continuous training and updating of knowledge and skills, new training models are emerging. Industry representatives described three new ways of thinking about the role of schools, specifically community colleges, in this process. Community colleges need to partner with industries, offer new courses and content, and develop new models for maintaining up-to-date curriculum and staffing.

- **Community college and industry partnerships.** Employers and colleges need to work together. Colleges find it hard to help teachers stay up-to-date on skills and curriculum and fail to support faculty in their efforts to stay abreast of this fast-changing industry. Industries can assist through externships (i.e., placing teachers in industry for short-term job experiences), providing facilities with the most up-to-date technologies, and by providing industry people who are knowledgeable to teach short-term classes and workshops.

- **Offer new courses and content.** Second, students need to have access to field and internship experiences that industry has defined as critical to job success. Through community college and industry partnerships, these types of experiences for students can become a reality. Additionally, given the changing work environment, students need to learn "meta-skills" for careers. Seminars in hiring negotiations, job hunting, and job acquisition are becoming an increasingly important part of the workforce preparation environment. Faculty will need to learn to value these components of a community college program and to integrate it throughout technology training programs.

- **Develop new models for maintaining up-to-date curriculum and staffing.** Finally, traditional community college processes for curriculum delivery and development will not meet these increased demands of a fast-paced changing industry. Solutions involve Internet deployment of classes (i.e., "you've got Zip Davis University which is just a box, a closet somewhere with a dozen servers sitting in it, but it's a university that puts out a curriculum, puts out an education") and working with current college systems to "fast track" course development and approval. As an industry representative observed,

  > *Anything you could possibly find 10 years ago, on any of these subjects [information technology], would be totally obsolete. And anything you teach now will probably be totally obsolete in five years. Can all of this development process keep up with that? Windows 2000 was released in February. If you had done this process a year ago, it would have been Windows 1994, but that's obsolete, all of a sudden. We do this process two years from now, it's going to be Windows 2001. Can the curriculum development process and coordination of the different players in the process work fast enough to keep up with that?*

Additionally, community colleges will start to reflect the business models of the technology industry. If finding enough trained workers in information technology is a challenge, finding faculty to train them is a bigger one. Institutional constraints, such as collective bargaining and across the board salary levels, make it difficult for colleges to compete with industry in attracting qualified people to teach courses. An industry representative commented that,

> *I came here from out of state to work for [a large company]. I made significantly more money as a hired gun for a community college there, than their regular faculty. But I didn't know from quarter to quarter what I was going to teach. Or if I was going to at all. In California, that's not a reality.*

Summary

Overall, these six "over-the-horizon" trends describe a rapidly changing workplace. Rather than being static and predictable, work environments are dynamic and structured differently than in the past. An eight-to-five job is a thing of the past, instead companies staff 24 hours a day, seven days a week and use shift work and a 20- or 24-hour helpdesk as strategies to meet customers' unceasing needs. Workers are becoming more entrepreneurial and, as companies demand more time, may adopt a strategy of working hard, long hours, collecting bonuses tied to their productivity and stock options, then cashing out and retiring early. Nothing is permanent in this environment, a job may suddenly be obsolete, a recession could come and change everything, a company could disappear or start-up overnight. To survive and thrive in this environment, workers need to have initiative, stay on top of new technologies and products, and train themselves into new jobs and careers.

Industry representatives voiced a sense of urgency and concern with keeping pace with change in this environment. Workers need to embrace change, try to stay ahead of the momentum, and, essentially, "ride the wave." As an industry reviewer advised,

Yes, you're going to ride somewhere on that side of it [with the momentum], because there's always going to be somebody who's going to push it. You're never going to be in advance of the wave. The best you can hope for is to not be drowned by it, or left behind by it.

Recommendations

Overall, the analysis of the focus group data leads to the following general recommendations to the project regarding curriculum development.

1. Community colleges and industry should work together in establishing long-term relationships and partnerships. Specifically, the project should involve larger companies who have established ties to education and their own training programs (e.g., Intel, National Labs, Sun). Through these partnerships, the community colleges can start to meet IT program needs in relation to student and faculty internships, sharing of facilities (e.g., expensive LINUX workstation labs) and recruiting short-term faculty from industry.

2. The community colleges should work towards building partnerships within related divisions on their own campuses. As an industry reviewer in computer programming suggested, each community college should collaborate with colleagues in their CIS or IT divisions. These departments can help both in implementation and development of curriculum.

3. The project should continue to have industry review the IT curriculum and provide feedback to ensure an up-to-date and viable curriculum and program.

4. All curricula should specifically include non-technical competencies. In particular, reviewers targeted teamwork, communications, and problem solving.

5. An emphasis on life-long learning and entrepreneurial skills should infuse IT programs to prepare students to be successful in these ever-fluctuating, fast-paced work environments.

6. Community college instructors should stay in close touch with the fast changing IT industry. Instructors need to be aware of the "over-the-horizon" trends as these issues become characteristic of the industry and the most up-to-date technologies to best prepare students to participate in IT workplace environments.

7. Each curriculum should include a field-based component. Employers overwhelmingly placed value and importance on "real world" experience in the IT industry in regard to hiring decisions. Job-related experiences are particularly important for technical support and network administrator students.

APPENDIX

Questions for Review of Model Curriculum

- What elements of the model curriculum as shown in Figure 1 of the curriculum guide are most valuable or useful? Why? What components are least valuable or useful? Why?

- Is this the appropriate array of degree(s) and specialization(s)? Is there a significant area of emphasis left out? Would you recommend any changes?

- Is the course content appropriate for each degree? Is something significant left out? Should anything be changed or omitted?

- Which of the technical competencies are most valuable and useful? Why? Which are least valuable and useful? Why?

- Is it more important to emphasize the general principles of programming, network administration, or technical support or to emphasize being ready to work in one specific language, operating or networking system?

- Is it more important to learn a specific language, operating, or networking system in depth or be versed in multiple ones? If specific, which one?

- Do the names that we have selected for each degree and specialization make sense? If not, what name is more appropriate?

- Would you hire a graduate of this program? Why? Would you recommend this program to someone interested in preparing for a career in information technology? Why?

Additional Questions

- What are the advantages of the following delivery systems for this curriculum? Disadvantages? Preferences?

  - Morning classes
  - Evening classes
  - Weekend classes
  - Distance education

- What is your estimate of the potential job market in this IT field each year? How difficult is it to find qualified people to fill these jobs?

- Is there a career path (vertical or lateral) in this area? What skill sets would you look for in promoting an employee in this area (i.e., managerial or technical skills)? What is the potential for advancement?

Questions for Industry Certifications and Community College Certificates and Degrees

- You are considering three applicants for a programmer/analyst, network administrator, or technical support position with your company. One has an AA/AS degree, one has a community college certificate, and one has an industry certification in a relevant skill [e.g., Cisco Certified Network Administrator (CCNA), Microsoft Certified Software Engineer (MCSE), A++]. Which applicant are you most likely to hire? Why or why not?

- Would it make a difference if the applicant had a 4-year degree?

- What is the best combination of degrees and certifications?

- Would it make a difference in employee advancement if the employee had a 4-year degree? An AA/AS degree? A community college certificate? An industry certification?

Non-Technical Competencies

- Which are the most important of the non-technical competencies for the degree(s) and specialization(s)? Why? Which are the least important? Why? Have we left anything out? Should anything be dropped or omitted?

- For those competencies identified as most important, what activities or tasks reflect that competency in the workplace? Please give an example.

"Over the Horizon" Questions

- Where do you see the industry in…

  - 6 Months
  - 1 Year
  - 3 Years
  - More than 3 Years

- What do you see in relation to…

  - Industry Trends
  - Technology Trends
  - Labor Markets

- What might we want to be teaching in emerging technologies?